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USSR TRENDS IN ULTRASONIC RESEARCH APPLIED TO CHEMISTRY

[Numbers in parentheses refer to appended sources.]

According to a statement made by S. Ya. Sokolov, USSR research on the application of ultrasonic methods in general and on their application specifically in the chemical field will be influenced by the recent discovery of the piezoelectric properties of barium titanate, a substance which exhibits a much stronger piezoelectric effect than quartz.(1) The piezoelectric properties of barium titanate were discovered by B. M. Vul, Corresponding Member of the Academy of Sciences USSR, who together with his collaborators has done extensive work on this substance. According to Vul, the manufacture of barium titanate is extremely simple from the technological standpoint: it can be produced without great difficulty in any desired shape and thickness. Vul has reviewed his work on barium titanate in a report presented at the Conference on the Location of Defects by Means of Ultrasound and General Problems of Ultrasound Acoustics. The conference was called by the Commission on Acoustics, Academy of Sciences USSR, and held at Moscow in 1953.(2)

S. Ya. Sokolov, who is regarded in the USSR as a pioneer and foremost authority in the field of applications of ultrasound for the detection of defects in materials used in construction and engineering, has also done a considerable amount of work on the applications of ultrasound in chemistry. Thus, he is credited with work on the application of ultrasound to promote crystallization in chemical processes.(2) A precise method of measuring changes in the velocity of ultrasound, which has been developed by S. Ya. Sokolov, makes it possible to investigate or observe the course of chemical reactions and to determine exactly the duration of the reactions investigated, irrespective of the time necessary for their completion, which may amount to hours or microseconds. Sokolov's method can be applied to reactions taking place in any medium. The medium may be solid, liquid, or gaseous; it may be transparent or opaque to light. In kinetic determinations of this type, the intensity of the ultrasound vibrations can be regulated so that they will have no effect on a course of the chemical reaction. S. Ya. Sokolov gives the information that

has been outlined above in a recently published article and furthermore mentions there that the course of polymerizations can be studied most conveniently by means of ultrasound, because the velocity of the propagation of the sound vibrations and the coefficient of viscosity change fastest during polymerizations.(1) Elsewhere he describes application of his method to the study of the kinetics of the oxidation of phosphorus and the inversion of cane sugar.(3) More detailed information on S. Ya. Sokolov's procedure for the study of the kinetics of reactions is given in an article that was published by him earlier.(4)

According to S. Ya. Sokolov, the use of the ultrasound microscope developed in the USSR in 1950 (5) makes possible the direct observation of many physical phenomena which have a bearing on chemical processes, i. e., the adhesion of films, development of gas bubbles in electrolysis, the flow of heat currents and diffusion currents in liquids, etc.(1)

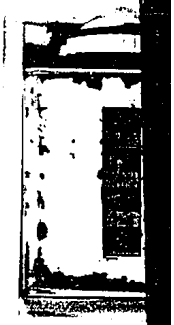
In reviewing the subject of ultrasound at the Conference on the Location of Defects by Means of Ultrasound and General Problems of Ultrasound Acoustics, N. N. Andreyev, Corresponding Member of the Academy of Sciences USSR and Chairman of the Commission on Acoustics at this Academy, in addition to mentioning S. Ya. Sokolov's work on the use of ultrasound for the purpose of inducing crystallization, enumerated applications of ultrasound for the following purposes: coagulation of smokes, clearing of fog, coagulation of colloids, medical diagnosis and therapy, and destruction of bacteria and other living cells.(2)

In connection with Andreyev's reference to the fact that ultrasound destroys bacteria, a statement made in a popular article to the effect that ultrasound can be used to sterilize water may be significant from the standpoint of practical application.(5)

In another report presented at the conference mentioned above, B. B. Kudryavtsev discussed the application of ultrasound for the determination of the duration of molecular collisions in gases on the basis of a theory developed by A. S. Predvoditelev. In this report, he also discussed the use of ultrasound techniques for the determination of molecular weights of liquid substances and of the structure of molecules (for instance, their degree of branching), the determination of the interaction between molecules of various components of mixtures dissolved in water, measurement of the mass of solvated ions, and studies of diffusion.

In an extensive report given at the same conference, N. N. Dolgopolov told about applications of ultrasound in chemistry and technology. After referring to the progress achieved in the USSR in the applications of ultrasound, to the field of chemistry, Dolgopolov discussed the theory of cavitation and the nature of the chemical effects produced by cavitation. This discussion was based on work done by a number of USSR investigators (Ya. I. Frenkel', G. L. Natanson, V. L. Levshin, and S. N. Rzhevkin). Dolgopolov mentioned that decomposition of halogen derivatives of hydrocarbons, hydrogen sulfide, carbon bisulfide, aromatic hydrocarbons, azides, and other compounds, is brought about by ultrasound. He further pointed out that the action of ultrasound on aqueous solutions of organic compounds results in significant changes of the hydrogen ion concentration. Dolgopolov stated that the effect which ultrasound exerts on chemical reactions is not due merely to the fission of compounds and oxidation, but is due also to the activation of molecules brought about by cavitation and to the mixing produced by ultrasound. He gave as an example of this type of effect the sharp increase in the rate of hydrolysis reactions and of the saponification of fats (N. N. Dolgopolov, Ye. I. Gorlinskaya).

In connection with the application of ultrasound in physicochemical processes, Dolgopolov furthermore pointed out the following facts: sulfur, tin, copper, mercury, and paraffin wax can be dispersed in water by means of ultrasound; very finely dispersed stable pharmaceutical emulsions and suspensions (e.g. camphor



or camphor oil in alcohol, sulfidine preparations in water, albichtol in water) can be prepared; coal can be dispersed in fuel oil to produce a suspension for use as fuel; in suspensions subjected to the action of ultrasound, the temperature of suspended particles is always higher than the average temperature of the mixture (this is a phenomenon similar to the inhomogeneous heating of suspensions exposed to high-frequency electromagnetic vibrations); and technological processes have been developed for the chemical processing of motion-picture films with the aid of ultrasound and for the use of ultrasound in cleaning raw wool prior to weaving (N. N. Dolgopolov, V. M. Fridman, Ye. I. Gorlinskaya, Ye. L. Ruban).(2)

Some prospective and actual applications of ultrasound in the USSR were recently discussed by A. N. Nesmeyanev, President of the Academy of Sciences USSR, in the following words: "Research on the propagation of ultrasound in gases, liquids, and solid bodies has led to the discovery of phenomena which are of great importance from the standpoint of practical applications. For instance, using the phenomenon of the reflection of ultrasound from the boundary between media having different elastic constants, one may with the aid of electronic appliances determine the thickness of the walls of boilers or reaction kettles, measure the dimensions of manufactured articles, and carry out other measurements of a similar type when access to the object to be measured is possible only from one side. On the basis of the interdependence between the rates of propagation and extinction of sound and the physical state [of the material], or the composition of a mixture consisting of a liquid and gases, very simple and cheap methods for the automatic control of production processes in machine building and in the chemical and food industries have been developed. An ultrasound microscope has been devised which makes it possible to conduct observations within opaque liquids and solid bodies. By acting on metals with powerful ultrasonic radiation, one may develop effective methods of improving their structure. One may furthermore precipitate smokes and dust with the aid of powerful ultrasonic irens. By applying ultrasound one may also obtain important emulsions for industrial use, produce new biological preparations, and sterilize water or milk."(7)

The statement made by Nesmeyanov in regard to the automatic control of industrial processes by means of ultrasound is particularly interesting. Applications of this type would presumably be based on S. Ya. Sokolov's work. A device for the measurement of the thickness of the walls of boilers and of other equipment has been designed by V. S. Sokolov.(2) V. S. Sokolov mentioned as one of the applications of this device the measurement of the corrosion of inner surfaces.

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